LETTERS TO THE EDITOR.

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The Nature of the γ and X-Rays.

IN a previous letter to NATURE (January 23, p. 270) I gave a brief description of some experiments made by Dr. Madsen and myself on the properties of the secondary radiation due to γ rays. A fuller account is given in the Transactions of the Royal Society of South Australia, 1908, p. 1.

The experiments have been continued, and I hope that the following summary of the results will be of interest:—

(1) When γ radiation is diminished in quantity as it passes through matter, β radiation appears in its place, moving at the outset in the original direction of the γ radiation, and subsequently undergoing scattering in the ordinary manner of β rays.

(2) The penetration and therefore the speed of the β radiation thus produced increases with the penetration of the γ radiation to which it is due.

(3) The speed of the β radiation does not depend upon the nature of the atom in which it arises.

(4) In the case of radium at least, the speed of the β radiation is nearly equal to, perhaps a little less than, the speed of the normal β rays emitted by radium itself.

(5) When very hard γ rays traverse matter their absorption and therefore the production of β rays are almost independent of the atomic structure of the matter, and a density law follows. Softer rays are affected by atomic structure; they are more absorbed by heavy atoms than by light atoms for equal weights of absorbing screen. The softer the rays, the greater is this effect. Hence arises the difference in character of the logarithmic curves of absorption of different substances; heavy atoms show a rapid initial fall. Hence also when soft γ rays are used the emergence radiation from heavy atoms may be greater than from light atoms. And again, the relative extent to which the rays produce secondary radiation from different metals may be modified by passing the rays through screens, as Kleeman has shown. We do not, however, find any true selective absorption such as Kleeman suggests.

(6) If there are any secondary γ rays, the ionisation which they produce is negligible compared with that produced by the secondary β radiation, at least within a moderate distance of the radiator, say a metre in air.

All these facts can be explained very simply and directly on the neutral-pair theory; indeed, the theory guided us to the verification of most of them.

As regards (1), we have simply to suppose that the negative and positive passing united into an atom are separated if they happen to traverse a very strong field anywhere therein; the negative flies on, and the positive becomes ineffective.

The second property is also an obvious consequence of the hypothesis. The faster the γ particle is moving, the greater the initial speed of the negative.

The third is readily explainable: the electric field of the atom is merely the solvent of the bonds that connect the pair. It is not able to affect the speed of the negative set free.

The fourth may be taken to imply that the radio-active atom (say Ra C) ejects electrons at a certain speed, some of which start off in company with a positive counterpart, some without. The former constitute the γ rays, the latter the β.

The fifth would show that there are stronger fields inside heavy atoms than light ones, and that the chance of separation of the pair increases with (*a*) the strength of the field, (*b*) the time taken to cross it.

Turning now to the ether pulse hypothesis, it is convenient to consider it in two different forms, which are irreconcilable with each other.

In the first of these, both the electron and the electron's energy are supposed to be drawn from the atom, the γ ray merely pulling the trigger. This theory requires us to accept the extraordinary idea that the primary ray, though it does no more than pull the trigger, determines the direction and velocity of the shot, and it offers no explanation at all of (1) and (4) (see above). We should naturally expect the velocity of the electron to be a function of the properties of the atom from which it is drawn, as in the well-known cases of true radio-activity. Moreover, all the radio-activity of which we have certain knowledge is not to be hurried or stayed by any external agency. It is true that Prof. W. Wien (Göttingen *Nachrichten*, 1907, p. 598) has made a tentative application of a theory of Planck's, and thence derived a formula $v^2\lambda=\text{const.}$, where v is the velocity of the ejected electron, and λ the thickness of the pulse. This provides a formula, but it satisfies (2) and (3) only; moreover, it seems to me that the difficulties remain as great as ever, and that the application of Planck's theory must be unjustifiable.

Passing on to the second form of the pulse theory, we now suppose the electron itself to be drawn from the atom, but its energy from the pulse.

I understand that this view is now held by Prof. J. J. Thomson (see Camb. Phil. Soc., vol. xiv., part iv., p. 417), and it is also maintained by Mr. N. R. Campbell ("Modern Electrical Theory"). New works often take some time to reach us here, and I have only just received a copy of this admirable book, but I hope I have understood it sufficiently well to enable me to describe the position correctly.

Since the energy of a pulse, if spread over an ever-widening surface, is utterly insufficient to provide the energy required for the secondary β ray, Prof. Thomson and Mr. Campbell suggest that the pulse does not spread, but travels radially from the arrested electron along tubes of force, the latter being considered as things differentiated from the surrounding space. Prof. Thomson speaks of bundles of pulse energy travelling with the speed of light in straight lines. When a kathode particle strikes the anti-kathode, bundles dart away from the point of impact; when these impinge on atoms they drive out the electrons constituting the secondary rays. In this way the energy difficulty is explained, and possibly also the difference between the emergence and the incidence radiations. It must be remembered, however, that this difference may be very large. In the case of carbon under γ rays, the one radiation is five or six times the other. Since the secondary β ray has the same speed (nearly) as the primary kathode ray which caused the X-ray, it seems to me necessary to suppose that the arrest of the kathode particle must cause one bundle of energy of very small and invariable volume to travel out along one straight tube (and only one) connected to that particle. This causes the ejection of one electron from some atom into which it penetrates, giving all its energy to that electron. Similar arguments apply to β and γ rays. Surely it requires a very complicated structure of the æther to effect all this. I have too deep a respect for Prof. Thomson's work to say it is not possible to construct a theory on these lines, but I think I may fairly claim that the neutral-pair theory explains all the known properties of the γ rays much more simply and completely.

Perhaps I ought to add that the theory, although it may require a detachable positive electron, does not require a free positive electron.

I have scarcely mentioned the X-rays. I am glad to see that Mr. Cooksey (NATURE, April 2, p. 509) has proved the difference between emergence and incidence radiation in their case also. It can now be said, therefore, that all the properties of the γ rays as set out in the above summary hold for the X-rays also, ***mutatis mutandis.***

University of Adelaide, May 5. W. H. BRAGG.

Symbols for Physical Quantities.

IT is very desirable to have a notation for the representation of physical quantities in scientific books and periodicals, which shall be the same in all languages.

The subject is under the consideration of the International Electrotechnical Commission with a view to international agreement, and committees in the different countries (in England under the chairmanship of Lord Rayleigh, O.M.)

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are discussing this particular subject. They are dealing more especially with symbols for electrical and magnetic quantities, but the system might with advantage be extended to embrace all important quantities in physical science, especially as the subject is receiving the attention of most technical societies with a view to some action being taken in the matter.

There are, however, two great difficulties which arise when we try to fix upon a standard notation.

The first is the difficulty of persuading a number of writers and readers who have become accustomed to a certain symbol for a certain quantity to change it in favour of an equally large number of writers and readers who have become accustomed to another symbol. For instance, in France and Germany the letter "I" commonly represents the strength of an electric current, while in England and America "C" is more commonly used.

In the second place, there are not enough letters in the two or three alphabets at our disposal to give a distinct symbol to each quantity, without resorting to the combination of more than one letter to form a single symbol. There is a great objection to this combination of letters, because the use of subscript letters and numbers is required for distinguishing between particular quantities of the same general kind. If, for instance, C represents current, C_a might conveniently represent armature current, and C_1 the current in circuit No. 1. It would therefore not be good to take C_a to represent capacity, or any quantity other than an electric current.

There is, moreover, an objection to using letters at all to represent quantities in a universal notation, because, unless initial letters are used, there is no connection in the mind between the letter and the quantity, and the symbol is difficult to remember. We cannot always use initials, because the initial letters differ in different languages. For instance, in England "R" commonly stands for resistance, while in Germany it is more convenient to use "W" for widerstand. Moreover, the same initial occurs for a great number of different quantites. For instance, "R" might stand for resistance, reluctance, reactance, radius, &c.

One way of avoiding the above difficulties would be to create a number of new symbols which could be printed by means of type like ordinary letters, and which would represent each physical quantity in a distinctive manner.

The question, however, arises as to whether a number of entirely new symbols would be acceptable to writers, readers, and printers alike, and the sub-committee on symbols appointed by the British section of the Commission has requested the writer to place his views publicly before the profession, with the view of obtaining suggestions and criticisms as to the feasibility of such a scheme from as wide a circle as possible.

In choosing a symbol, we would try to make a very simple picture of something that reminds us of the quantity in question. For instance, 🌡 might represent temperature. If we were told that this simple outline of a thermometer represents temperature, we would have no difficulty in remembering it. Similarly, / might represent force, and the various "forces" might be derived from it; for instance, ϟ electromotive force (conventional representation of lighting), and ∩ magnetomotive force.

It is not my purpose here to say what would actually be the best form of symboi for each quantity, but it is not a difficult matter to devise very simple characters which can be written quickly, easily, and with sufficient accuracy, and can at the same time assist the memory to connect them with the quantity for which they stand.

What would the printers say to the new type? The author has taken up this matter with a very large publishing firm, and is assured by their chief expert that 200 or 300 new types would be a small matter to a modern printer, who is already accustomed to deal with many hundreds of different founts, each of which contains from 50 to 120 different symbols. He estimates that a printer in a large way of business has at his command as many as 60,000 distinct types, differing from each other either in letter, size, body, or face. The addition of 200 or 300 more would be a drop in the ocean. The size of the new type could be standardised for most purposes, and it would only be in some special case that another size would be called for.

The setting up of the formulæ with the standard size of type would be simpler than with the present system, in which subscript letters are often unnecessarily introduced. One symbol under the present system sometimes consists of four or five letters.

If it be admitted that the introduction of new symools is advisable, the question arises, what shall the new symbols represent exactly? Shall the sign 🌡 (temp.) represent temperature in any units, or shall it represent the number of degrees of temperature, measured by some scale agreed upon, and embodied in the definition of the symbol? If the system of units employed be not prescribed, fewer symbols would be required, and the general writer who now says vaguely, "Let T equal the temperature," would find the symbol sufficient for his purpose. But from the reader's point of view there is much to say in favour of a symbol which will embody in its definition a standard system of units. Any formula expressed in such symbols would be completely self-contained, and would be an exact statement of a physical fact. Until the units employed in any formula are known, the formula expresses only half its meaning. Perhaps some slight addition to the symbol, or even to the whole formula, might be used to indicate that the standard system of units is employed. Without that addition, the symbol would have a general meaning. For instance, 🌡 might equal temperature, while ⸸ might indicate the degrees centigrade above the absolute zero. The name of the type might be the name of the physical units which it represents; for instance, for ϟ we might read "volts."

If writers, printers, and readers who have any definite views as to the best method of devising a system of symbols would communicate with the author, they might assist in solving the many difficulties which arise in connection with this matter. MILES WALKER.

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Linnæus's Authorities.

I AM happily able to throw a little light upon the question raised by Prof. Karl Pearson in NATURE of July 16 (p. 247). The citation he quotes is identical with that in the tenth edition of the "Systema Naturæ" (1756), p. 24.

"Bont. jav. 84. t. 84." will be found in Piso, "De Indiæ utriusque re naturali et medica," Amst. 1658. fol. The bastard title following the engraved title-page has towards the bottom this line:—"Iacobi Bontii, Bataviæ in majore Java novæ medici ordinarii, . . ." hence, no doubt, the form employed by Linnæus. This forms the third separately paged part of the volume, and on p. 84 is a woodcut of the "Ourang Outang sive Homo silvestris," &c.

"Kœp. itin. c. 86" is doubtless "Kiöping (Nils Matson) En reesa genom Asia, ... &c. Wisingsborgh, 1667. 4to."; I am quoting from Drvander's Catalogue of Banks's Library, vol. i., p. 86.

"Dalin. orat. p. 5." is referred to in Amœn. Acad., vol. vi., p. 74 as "Dalin in oratione Acad. R. Holm. de hac:" &c. I have not verified the actual speech, but it should not be difficult to run it down in the early volumes of the Handlingar. B. DAYDON JACKSON.

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Elliptical Halos.

IN Pernter's "Meteorological Optics" the explanation of haloes, based on a consideration of refraction and reflection in ice-crystals, is given at some length. In particular the elliptical halo described by Mr. Cave in NATURE of July 16 (p. 247) is shown to be a form depending on the sun's altitude. If the sun is less than 25° above the horizon, the phenomenon appears as two arcs touching the 22° halo at its highest and lowest points. For altitudes greater than 70°, it is indistinguishable from the 22° circular halo.

It would be interesting to know if Mr. Cave observed the transition from the elliptical to the circular form.

E. GOLD.

3 Devana Terrace, Cambridge, July 16.

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